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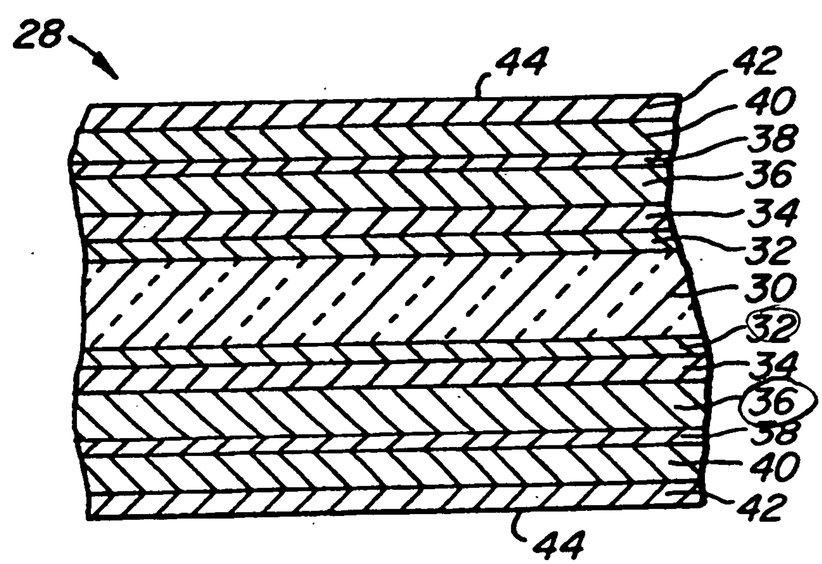

(57) Abstract

Magnetic recording media (28) which comprise non-metallic substrates (30) which are coated with an electrically conductive plating base layer (34) and optionally an adhesion layer (32). The base layer (34) and adhesion layer (32) permit deposition of an electroless nickel phosphorous layer (36) which is analogous to the nickel phosphorous layer on conventional aluminum magnetic recording discs. The nickel phosphorous layer may be textured and conventional ground (38), magnetic (40) and protective layers (42) formed thereover. In the exemplary embodiment, the adhesion layer (32) is a vacuum deposited chromium layer formed directly over the non-metallic substrate (30), and the electrically conductive plating base layer (34) is nickel phosphorous sputtered over the adhesion layer (32).

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MAGNETIC RECORDING MEDIA ON NON-METALLIC SUBSTRATES AND METHODS FOR THEIR PRODUCTION

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to magnetic recording media, and more particularly to magnetic recording disks formed on non-metallic substrates and methods for their production.

Thin film magnetic recording disks generally comprise a disk substrate having a magnetic layer and a number of underlayers and overlayers deposited thereon. The nature and composition of each layer is selected to provide desired magnetic recording characteristics as generally recognized in the industry. An exemplary present day thin film disk is illustrated in Fig. 1 and comprises a non-magnetic disk substrate 10, typically composed of an aluminum alloy. An amorphous nickel-phosphorous (Ni-P) layer 12 is formed over each surface of the disk substrate 10, typically by plating. The Ni-P layer is hard, and imparts rigidity to the aluminum alloy substrate. A chromium ground layer 14 is formed over the Ni-P layer 12, typically by sputtering, and a magnetic layer 16 is formed over the ground layer 14. The magnetic layer 16 comprises a thin film of a ferromagnetic material, such as a magnetic oxide or magnetic alloy. Usually, a protective layer 18, such as a carbon film, is formed over the magnetic layer 16, and a lubricating layer 20 is formed over the protective layer.

The presence of the Ni-P layer 12 and the chromium ground layer 14 has been found to improve the recording characteristics of the magnetic layer 16. In particular, a chromium ground layer formed over a Ni-P layer has been found to provide enhanced coercivity and reduced noise characteristics. Such improvements are further enhanced when the Ni-P layer is treated by

mechanical texturing to create a roughened surface prior to formation of the chromium ground layer. The texturing may be circumferential or crosswise, with the preferred geometry depending on the particular composition of the cobalt-containing magnetic layer.

Such magnetic recording disk constructions have been very successful and allow for high recording densities. As with all such successes, however, it is presently desired to provide magnetic recording disks having even higher recording densities. For reasons best explained elsewhere, recording densities can be improved by reducing the spacing between the recording transducer (read/write head) and the magnetic disk surface while the disk is rotating. Such closer spacing, in turn, requires magnetic recording disks which have very flat surfaces and which are dimensionally stable so that the surfaces remain flat during use. To this end, the use of dimensionally stable non-metallic disk substrate materials has been proposed, such as glass, ceramics, glass-ceramic composites, carbon, carbon-ceramic composites, and the like.

Such non-metallic disk substrate materials, however, suffer from their own disadvantages. In particular, it is difficult to texture many of these materials directly because of their surface hardness. While certain methods have been proposed for etching such hard surfaces, these methods generally result in isotropic etching which is less desirable than anisotropic etching for recording purposes. While it is theoretically possible to texture the surface of an Ni-P layer formed over a non-metallic substrate, such Ni-P layers have generally poor adhesion characteristics and therefore will not withstand many forms of texturing.

Another disadvantage of non-metallic disk substrate materials is their poor electrical conductivity. Such poor conductivity makes the sputtering or plating of subsequent layers, both of which

require electrical biasing, difficult. Additionally, glass substrates used for magnetic recording disks must be chemically strengthened so that they can withstand manufacturing and use. For example, glass surfaces may be subjected to potassium-sodium ion exchange process to strengthen the outer surfaces. Any texturing or other surface treatments of such strengthened glass substrates can therefore compromise the improved mechanical characteristics.

For these reasons, it would be desirable to provide improved methods for forming magnetic layers over non-metallic disk substrates in order to provide improved magnetic recording disks. It would be particularly desirable if such methods would provide magnetic recording disks having the improved mechanical characteristics derived from the non-metallic substrates while maintaining the enhanced magnetic properties available with aluminum and other metallic disk substrates. The methods should provide for texturing of the surfaces underlying the magnetic layers, should allow for the deposition of underlayers by sputtering and/or plating, and should permit the production of magnetic recording disks on glass and other substrates without mechanical degradation of the substrate surface.

2. Description of the Background Art

U.S. Patent No. 4,876,117, describes the use of nickel-phosphorous (Ni-P) underlayers on magnetic recording disks, and suggests that a wide variety of disk substrates may be employed, including aluminum, ceramics, glass, plastics, ceramic-metal composites, and glass-ceramic composites. No process description for applying Ni-P to substrates other than aluminum is provided. The use of a tin-nickel underlayer on an aluminum substrate is described in U.S. Patent No. 4,029,541. A Ni-P underlayer applied over a zincate layer on an aluminum disk substrate is described in U.S. Patent No. 4,929,499. Other underlayers for aluminum disk substrates are

described in U.S. Patent No. 5,047,274. U.S. Patent Nos. 4,598,017 and 4,376,963, describe composite disk substrates having polymeric cores. U.S. Patent No. 3,625,849, describes the use of cobalt-copper magnetic layers in hard disks. U.S. Patent No. 4,895,762, is of general interest.

SUMMARY OF THE INVENTION

According to the present invention, magnetic recording media are formed over non-metallic substrates by applying an electrically conductive plating base layer over the substrate surface. The electrically conductive plating base layer permits electrical biasing of the disk structure to facilitate application of subsequent layers by sputtering or plating. In a preferred embodiment, an adhesion layer is deposited directly over the non-metallic substrate surface prior to application of the electrically conductive plating base layer, where the adhesion layer helps anchor subsequently applied layers and further enhances electrical conductivity of the disk structure. Suitable adhesion layers are composed of Group IVB, VB, and VIB transition metals which may be deposited by methods which do not require electrical biasing, e.g. vacuum deposition. When using such metallic adhesion layers, the electrically conductive plating base layer will typically be sputtered nickel phosphorous (Ni-P) applied in a thin layer over the adhesion layer. The electrically conductive plating base layer acts as a base for subsequent application of a relatively thick Ni-P layer, which is typically deposited by electroless plating. The thick Ni-P layer can then be textured in a conventional manner to provide improved recording characteristics previously associated with the use of aluminum and other metallic substrates. The underlying electrically conductive plating base layer and optional adhesion layer further enhance recording characteristics and provide for the desired adhesion which anchors the Ni-P layer in place during texturing.

The remaining steps in forming the magnetic recording media include deposition of a magnetic layer, a protective layer, and a lubricating layer, in a generally conventional manner.

The present invention further provides magnetic recording media produced by the methods just described. Magnetic recording media according to the present invention will comprise a non-metallic substrate, an electrically conductive plating base layer formed over a surface of the substrate, an electroless plated Ni-P layer formed over the plating base layer, and a magnetic layer formed over the Ni-P layer, where the Ni-P layer has been textured prior to deposition of the magnetic layer. The non-metallic substrate may be composed of a variety of materials, including glass, ceramics, carbon, silicon, silicon carbide, and the like. In a preferred embodiment, the magnetic recording media will include an adhesion layer, such as a vacuum-deposited Group IVB, VB, or VIB metal, formed under the electrically conductive plating base layer.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a cross-sectional view of an exemplary prior art magnetic recording disk having an aluminum disk substrate, as described in the Background section hereinabove.

Fig. 2 is a cross-sectional view of a magnetic recording disk having a non-metallic disk substrate according to the present invention.

Figs. 3-5 show experimental data, as described in detail in the Experimental section.

DESCRIPTION OF SPECIFIC EMBODIMENTS

Referring now to Fig. 2, magnetic recording media according to the present invention will usually be in the form of a magnetic recording disk 28 comprising a non-metallic substrate 30, an adhesion layer 32, an electrically conductive plating base layer 34, a thick nickel phosphorous (Ni-P) layer 36, a ground layer 38, a

magnetic layer 40, a protective layer 42, and a lubricating layer 44. The various layers will be formed over at least one surface of the substrate 30, and preferably over both surfaces of the substrate 30, in the order illustrated. The non-metallic substrate 10 comprises a disk having a diameter suitable for formation of a conventional hard magnetic recording disk. Typically, the substrate 30 will be composed of glass, ceramic, carbon, glass-ceramic composites, glass-carbon composites, silicon, silicon carbide, and the like. Particularly preferred for use in the present invention is a glass substrate, such as the those available from Pilkington Micronics.

The adhesion layer 32 will typically be a vacuum-deposited metal layer, with suitable metals being selected from Group IVB, VB, and VIB of the Periodic Table. Particularly suitable metals include chromium, titanium, tantalum, vanadium, molybdenum, and the like. Vacuum deposition may be performed by conventional techniques using conventional equipment and has the advantage that it does not require electrical biasing of the non-metallic substrate 30. The thickness of the adhesion layer is not critical, typically being in the range from about 250 Å to 2500 Å, preferably being about 500 Å.

The presence of the adhesion layer is optional, although preferred. Other measures can be taken for assuring that the overlying electrically conductive plating base layer adhered to the substrate. For example, the substrate could be impregnated or seeded with certain salts, such as tin chloride and palladium chloride, as described by Vossen and Kein, *Thin Film Processes*, Academic Press, New York 1978, at page 221. Such impregnation, however, has the disadvantage that treated glass surfaces may be degraded, resulting in poor film adhesion. Alternatively, a metal adhesion layer

could be applied by screen pressing and subsequently melted to obtain a conductive layer.

The electrically conductive plating base layer 34 is next formed over the adhesion layer 32 (or alternatively over the adhesion-treated surface of the substrate 30). The electrically conductive plating base layer 34 will generally be a metal and will provide an electrically conductive surface for subsequent fabrication steps. Suitable metals and alloys include Ni-P, aluminum, platinum, copper, and the like. Preferably, Ni-P will be sputtered over the adhesion layer 32 to a thickness in the range from about 250 Å to 2500 Å, by conventional techniques.

The electrically conductive plating base layer 34 provides a plating base for the deposition of an electroless Ni-P layer 36. The electroless Ni-P layer is generally the equivalent of the underlying Ni-P layers found on conventional aluminum substrate recording disks of the prior art. The Ni-P will be deposited by conventional electroless techniques to a thickness generally in the range from 500 Å to 5000 Å. When chromium is used as the adhesion layer 32, it is necessary to control the temperature of the plating bath used to plate the Ni-P layer 36. It has been found that plating of Ni-P results in the evolution of hydrogen, which can cause incorporation of hydrogen in the chromium adhesion layer 32. Such chromium incorporation is undesirable since it interferes with adhesion between the chromium layer and the underlying non-metallic substrate 30. It has been found that bath temperatures below 100° C, preferably at or below 80°C, will generally avoid hydrogen evolution.

Once the Ni-P layer 34 has been plated, it can be mechanically textured in a conventional manner, such as by tape or slurry abrasion. The type of texturing will depend on part, on the nature of the magnetic alloy which is to be applied over the Ni-P layer 36. For

example, some magnetic alloys, such as cobalt-chromium-tantalum, require circumferential texturing to achieve optimum coercivity and magnetic anisotropy. Other magnetic alloys, such as cobalt-platinum-chromium, require other types of texturing. Specific texturing techniques are well known in the art and described in the technical literature. See, for example, Simpson et al. (1987) IEEE Trans. Magnetics, 23:3405, and Mirzamaannii et al. (1990) J. Appl. Phys. 67:4695, the disclosures of which are incorporated herein by reference.

Optionally, a ground layer 38 is applied over the textured Ni-P layer 36. The ground layer will typically be chromium or a chromium alloy such as CrB, or CrSi, which is deposited by sputtering onto the textured Ni-P layer. The ground layer will typically have a thickness in the range from about 500 Å to 2500 Å. The ground layer 38 further enhances the magnetic properties of the subsequently applied magnetic layer 40 by creating grain separation in the magnetic alloy.

The magnetic layer 40 is next applied over the ground layer 38, again typically by sputtering in a conventional manner. The magnetic layer will be composed of a cobalt-containing alloy, such as CoCrTa, CoPtCr, CoNiCr, core, and the like. The magnetic layer 38 may be a single layer or may comprise two or more layers formed over one another. The thickness of the magnetic layer 38 is not critical, typically being in the range from about 400 Å to 800 Å. The magnetic properties of layer 40 have been found to be dependent on thickness of the plated Ni-P layer 34, with thicker layers 34 producing more highly oriented magnetic films.

A protective layer 40 is next formed over the magnetic layer, typically being composed of carbon and having a thickness in the range from about 150 Å to 400 Å. The protective layer 40 will usually be coated with a lubricant layer 44, for example a fluorinated

polyether or the like, typically having a thickness in the range from about 10 Å to 50 Å.

The following example is offered by way of illustration, not by way of limitation.

EXPERIMENTAL

Polished soda lime glass disks (65 mm in diameter and 0.889 mm thick) were cleaned. A 1000 Å thick Cr adhesion film and 300 Å Ni-17 pct.P plating base film were sputter deposited. Then, a Ni-P film was electroless plated to a thickness of about 1000 Å. The plated film was found to have good adhesion and excellent surface quality. The plated glass substrate was textured using tape texturing process routinely used in thin film media manufacturing. The topography of the processed glass disks was very similar to the standard 10 micron Ni-P plated on aluminum substrates, as shown in Fig. 3.

A magnetic layer was deposited on the processed glass substrates by sputter depositing a 500 Å Cr underlayer, a 500 Å Co-Cr-Ta magnetic film, and a 250 Å carbon overlayer film. The magnetic layer had a 1500 Oe coercivity and an orientation ratio of 1.7 (Fig. 4). The electrical performance of processed glass disks was comparable to the disks synthesized on aluminum substrates. The durability of the glass media was evaluated using contact-start-stop-testing in a disk drive with thin film heads. The glass media did not show any wear after 50K contact-start-stops.

Magnetic disks were prepared as just described with plated Ni-P film thicknesses from 0 to 1 μm. It was found that thicker Ni-P layers provided enhanced magnetic orientation ratios. See Fig. 5.

Although the foregoing invention has been described in some detail by way of illustration and example, for purposes of clarity of understanding, it will be obvious that certain changes and modifications may be practiced within the scope of the appended claims.

WHAT IS CLAIMED IS:

1. A method for applying a magnetic layer on a non-metallic substrate, said method comprising:

applying an electrically conductive plating base layer over a surface of the substrate;

electroless plating of a nickel-phosphorous (Ni-P) layer over the plating base layer;

mechanically texturing the Ni-P layer; and

applying a magnetic layer over the textured nickel-phosphorous layer.

2. A method as in claim 1, further comprising applying an adhesion layer on the surface of the substrate prior to applying the electrically conductive plating base layer.

3. A method as in claim 2, wherein the adhesion layer is composed of a material selected from the group consisting of Group IVB, VB, and VIB metals.

4. A method as in claim 3, wherein the adhesion layer metals are applied by sputtering to a thickness in the range from 250 Å to 2500 Å.

5. A method as in claim 4, wherein the metal comprises chromium sputtered to a thickness in the range from 500 Å to 1500 Å.

6. A method as in claim 2, wherein the electrically conductive plating base layer is composed of a material selected from the group consisting of Ni-P, aluminum, platinum, and copper.

7. A method as in claim 6, wherein the base layer material is Ni-P applied by sputtering to a thickness in the range from 250 Å to 2500 Å.

8. A method as in claim 2, wherein the electroless Ni-P layer is plated to a thickness in the range from 500 Å to 5000 Å.

9. A method as in claim 2, wherein the electroless Ni-P layer is mechanically textured by tape or slurry abrasion.

10. A method as in claim 2, further comprising applying a protective layer and a lubricating layer over the magnetic layer.

11. Magnetic recording media comprising a non-metallic substrate; an electrically conductive plating base layer formed over a surface of the substrate, and electroless plated nickel-phosphorous (Ni-P) layer formed over the plating base; and a magnetic layer over the Ni-P layer, wherein the Ni-P layer has been textured prior to deposition of the magnetic layer thereover.

12. Magnetic recording media as in claim 11, wherein the non-metallic substrate is composed of a material selected from the group consisting of glass, ceramic, carbon, silicon, and silicon carbide.

13. Magnetic recording media as in claim 11, further comprising an adhesion layer formed over the substrate surface below the plating base layer.

14. Magnetic recording media as in claim 13, wherein the adhesion layer is composed of a material selected from the group consisting of Group IVB, VB, and VIB metals.

15. Magnetic recording media as in claim 14, wherein the adhesion layer is sputtered chromium having a thickness in the range from 500 Å to 1500 Å.

16. Magnetic recording media as in claim 13, wherein the electrically conductive plating base layer is sputtered Ni-P having a thickness in the range from 250 Å to 2500 Å.

17. Magnetic recording media as in claim 13, wherein the electroless Ni-P layer has a thickness in the range from 500 Å to 5000 Å.

18. Magnetic recording media as in claim 13, wherein the electroless Ni-P layer is circumferentially textured.

19. Magnetic recording media as in claim 13, further comprising a protective layer and a lubricating layer over the magnetic layer.

20. Magnetic recording media comprising a glass substrate, a sputtered chromium adhesion layer over a surface of the glass substrate having a thickness in the range from 500 Å to 1500 Å, a sputtered nickel-phosphorous (Ni-P) electrically conductive plating base layer over the adhesion layer having a thickness in the range from 250 Å to 2500 Å, a circumferentially textured electroless Ni-P layer plated over the plating base layer having a thickness in the range from 500 Å to 5000 Å, a magnetic layer formed over the electroless Ni-P layer, a protective layer over the magnetic layer, and a lubricating layer over the protective layer.

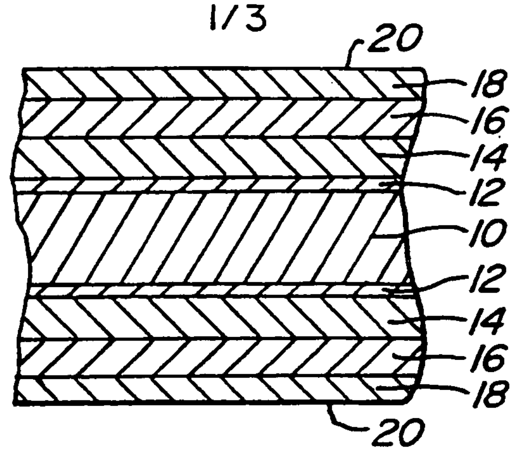


FIG. 1. PRIOR ART

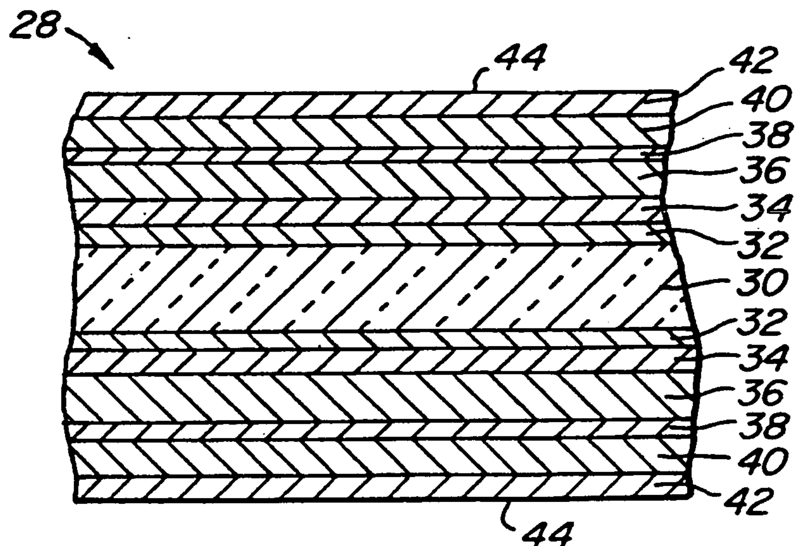
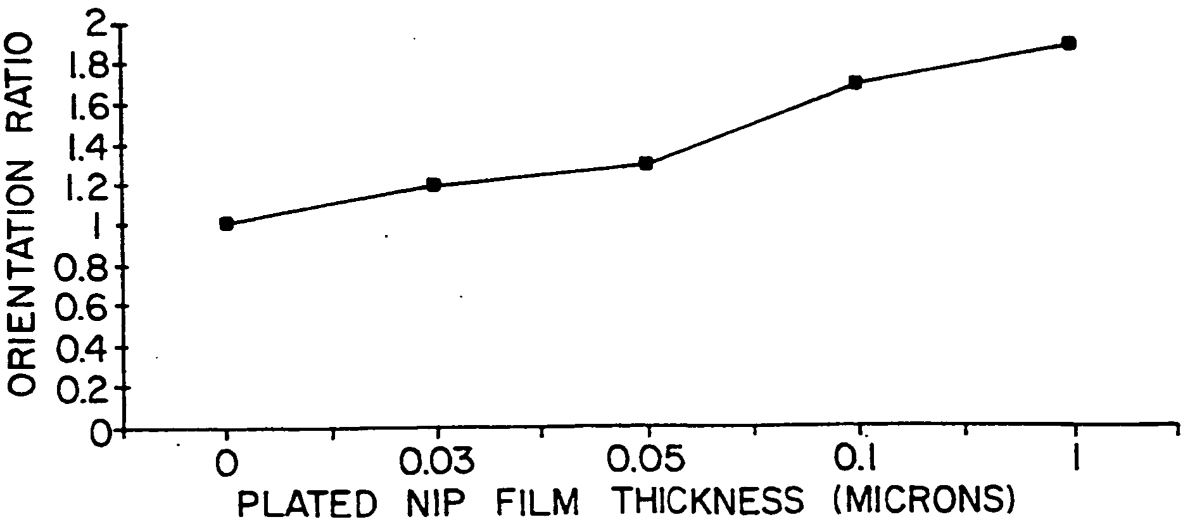


FIG. 2.



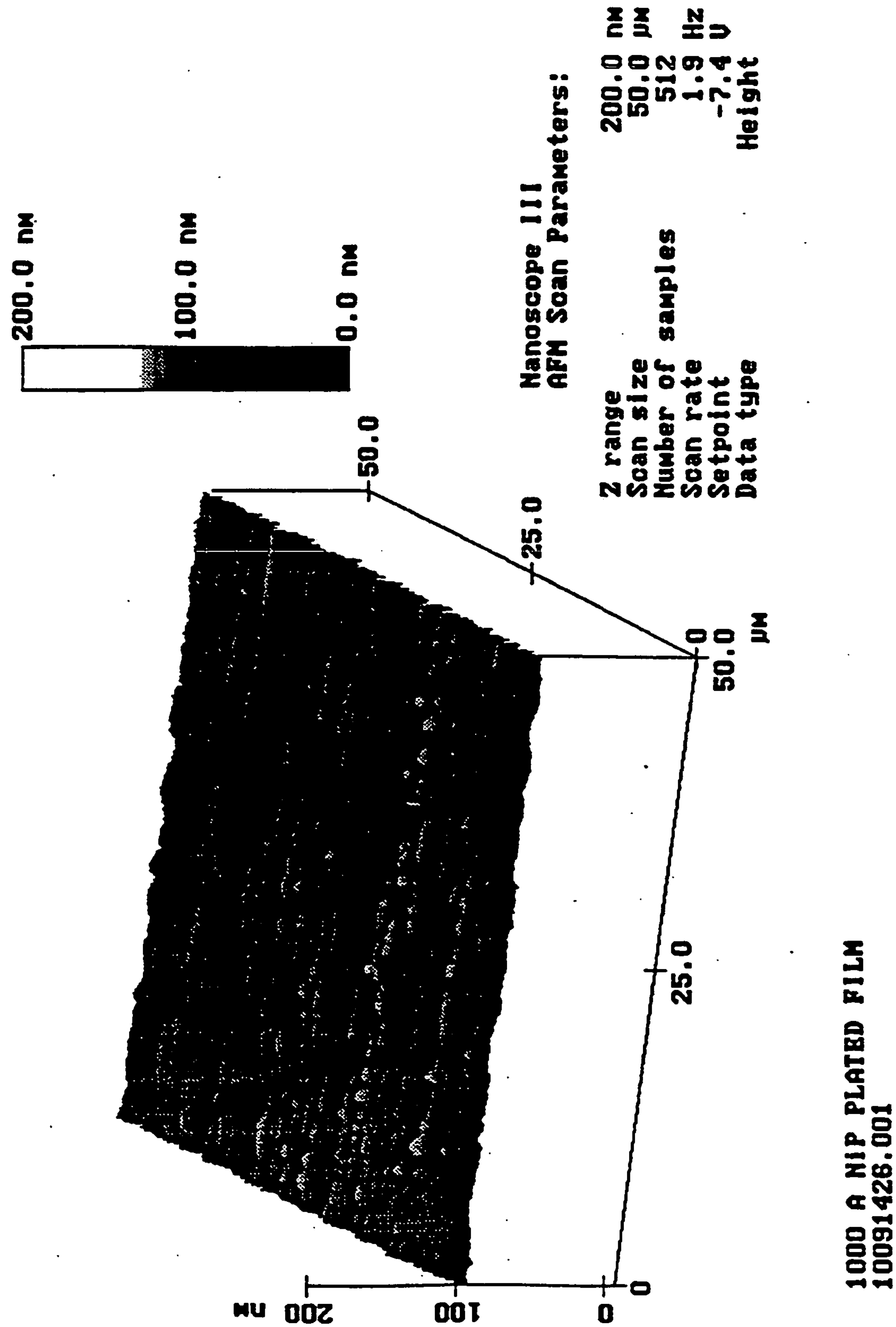

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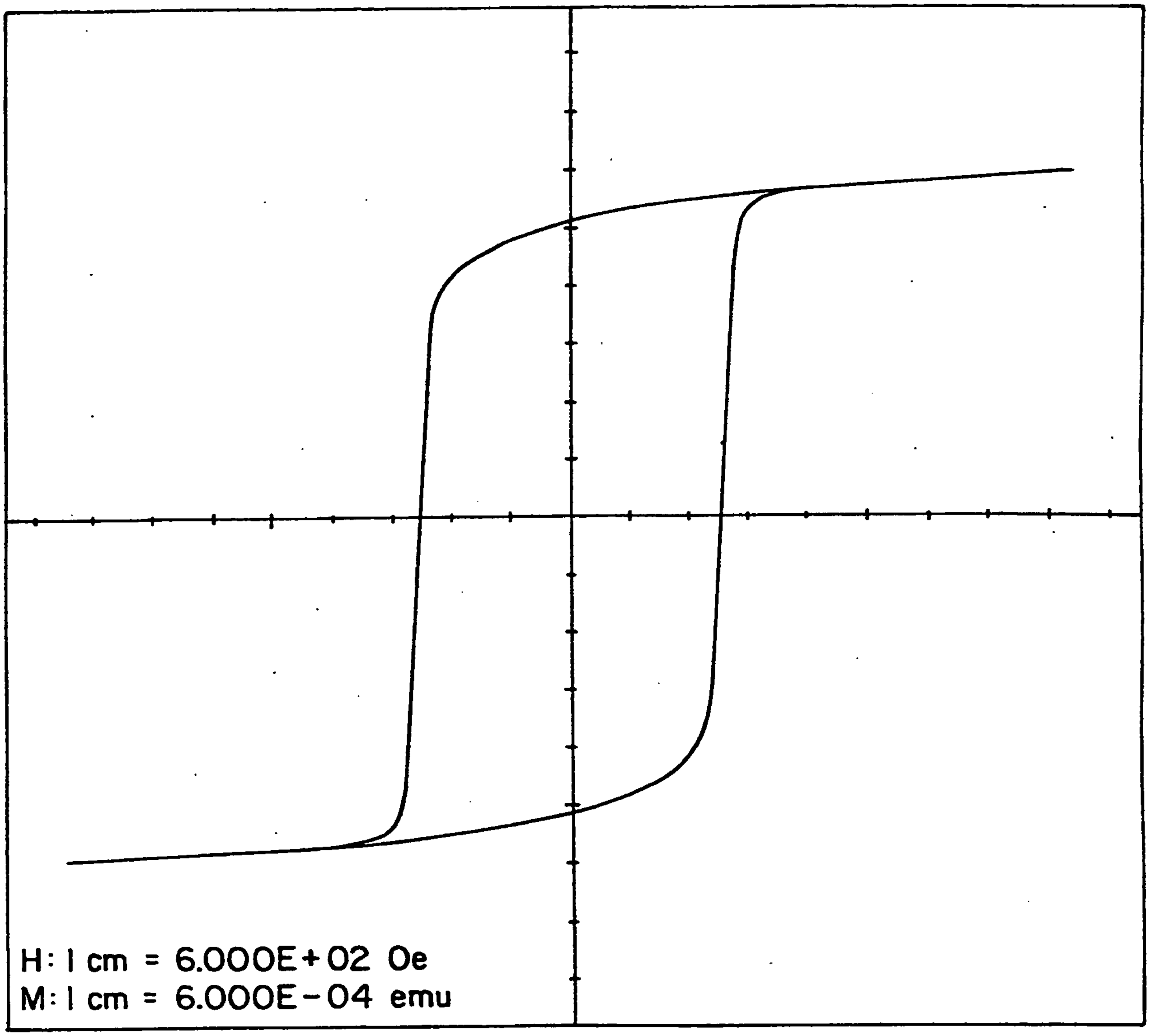
FIG. 3.



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CHI : -1.597E-08
LA : 4.025
HC : 1524.7 Oe
DELH: 195.8 Oe
SFD : 0.128
FILE: 4A-0
KR : 0.859

FIG. 4.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US94/00328

A. CLASSIFICATION OF SUBJECT MATTER
IPC(5) :BO5D 1/18, 5/12; G11B 5/66; C23C 14/00
US CL :Please See Extra Sheet.
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED
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U.S. : 204/192.1, 192.12, 192.14, 192.2; 427/129, 130, 132, 437, 438, 443.1; 428/694TS, 694SL

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	JP, A, 57-18029 (HITACHI KK) 29 JANUARY 1982; Abstract.	1, 11 2-6, 8-10, 12-15, 17-20
X Y	US, A, 4,786,564 (CHEN ET AL) 22 NOVEMBER 1988; Claims, Col. 7, lines 3-21.	11, 12 1-10, 13-20
Y	US, A, 4,876,117 (BORNSTEIN) 24 OCTOBER 1989, col. 2, lines 59-68.	1-20

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"&" document member of the same patent family

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31 MARCH 1994	23 MAY 1994

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INTERNATIONAL SEARCH REPORT

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A. CLASSIFICATION OF SUBJECT MATTER:
US CL :

204/192.1, 192.12, 192.14, 192.2; 427/129, 130, 132, 437, 438, 443.1; 428/694TS, 694SL